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MANNED SPACE FLIGHT NETWORK PERFORMANCE ANALYSIS FOR THE SA-6 MISSION

SEPTEMBER 1, 1964

NASA
GODDARD SPACE FLIGHT CENTER
GREENBELT, MD.

Manned Space Flight Network

Performance Analysis

for the SA-6 Mission

September 1, 1964

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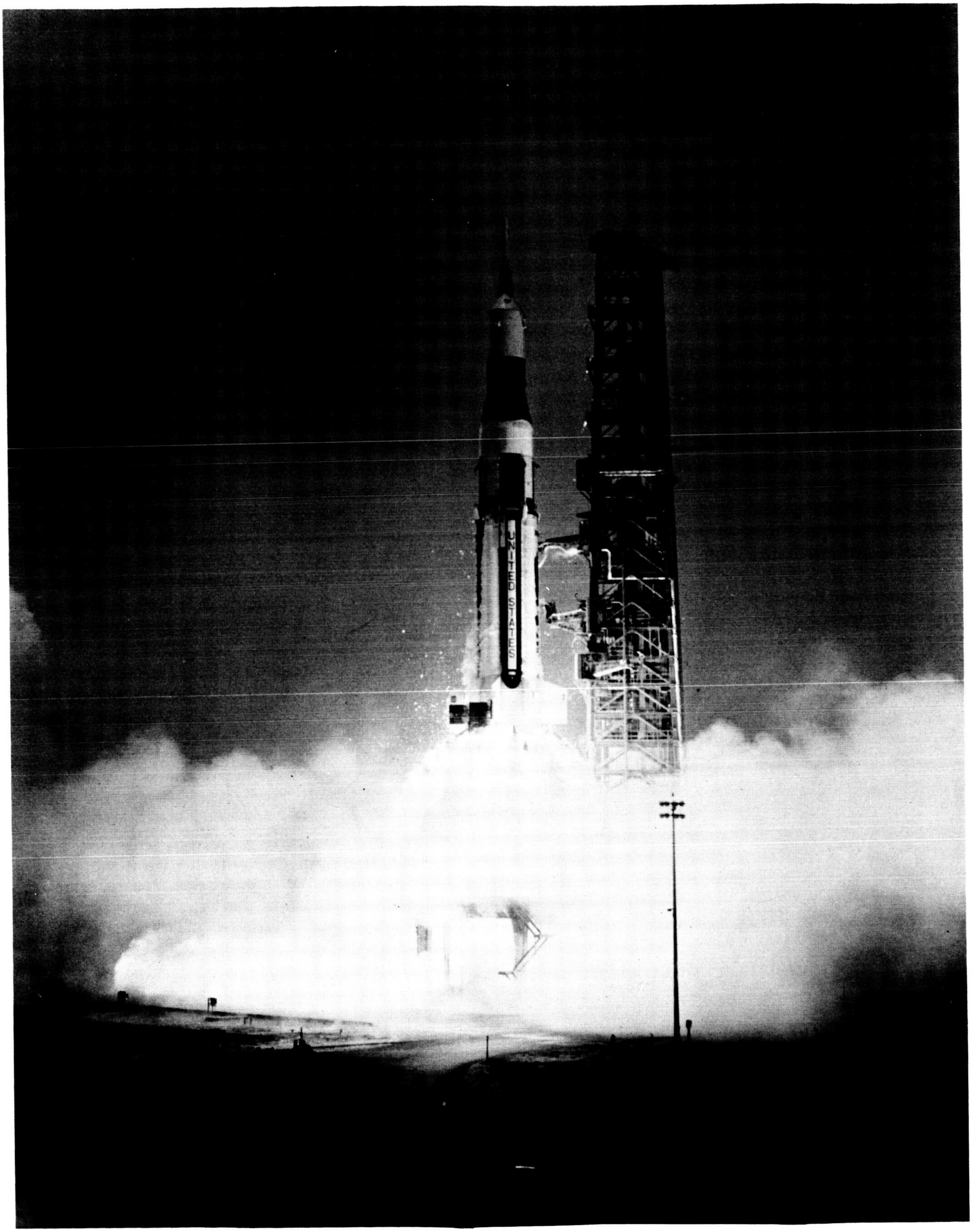

Liftoff of SA-6 Vehicle, May 28, 1964, Cape Kennedy

SUMMARY

The SA-6 mission was conducted to evaluate the design of the Saturn launch vehicle and the Apollo spacecraft systems under operational conditions, to test the compatibility of the Saturn-Apollo configuration during launch and injection into orbit, and to test the structural soundness and aerodynamics of the spacecraft.

The responsibilities of the Manned Space Flight Network (MSFN) were (1) to beacon track and, after beacon expiration, to skin track the vehicle for the duration of the mission, (2) to receive and record telemetry data, and (3) to provide computer support during the launch phase and throughout the orbital life of the spacecraft—this support to include transmission of computer data for display at the Mission Control Center.

In addition to the support provided by MSFN, other networks participated, i.e., STADAN, SAO, and NORAD. Also, NASA's Wallops Station provided radar (Spandar) support; and NASCOM provided the ground communications.

Prelaunch tests to certify network readiness went smoothly, and at the time of launch—17:07:00 GMT, May 28, 1964—all required network support systems were GREEN.

Network functions throughout the orbit and decay were very smooth, and the network support from launch to splash in the North Pacific Ocean on June 1 (0030 GMT) was excellent. The mission lasted for 3 days, 7 hours, and 24 minutes.

For the first time NASCOM used its new Univac 490 communications processor for mission traffic. All components of this automatic switching system performed excellently. The most significant communications problem encountered was during reentry, when Santiago experienced interference on its TTY link. However, the essential information was passed by voice. In spite of the interference on the circuit, the data was understood and proved to be of importance.

Also for the first time, the Goddard computing center mixed minitrack and radar data. The results showed that minitrack data can be used to confirm the orbital parameters and up-date predictions.

This was the third mission that skin track was accomplished on a real-time basis for computer data, and the effort was again successful beyond expectation.

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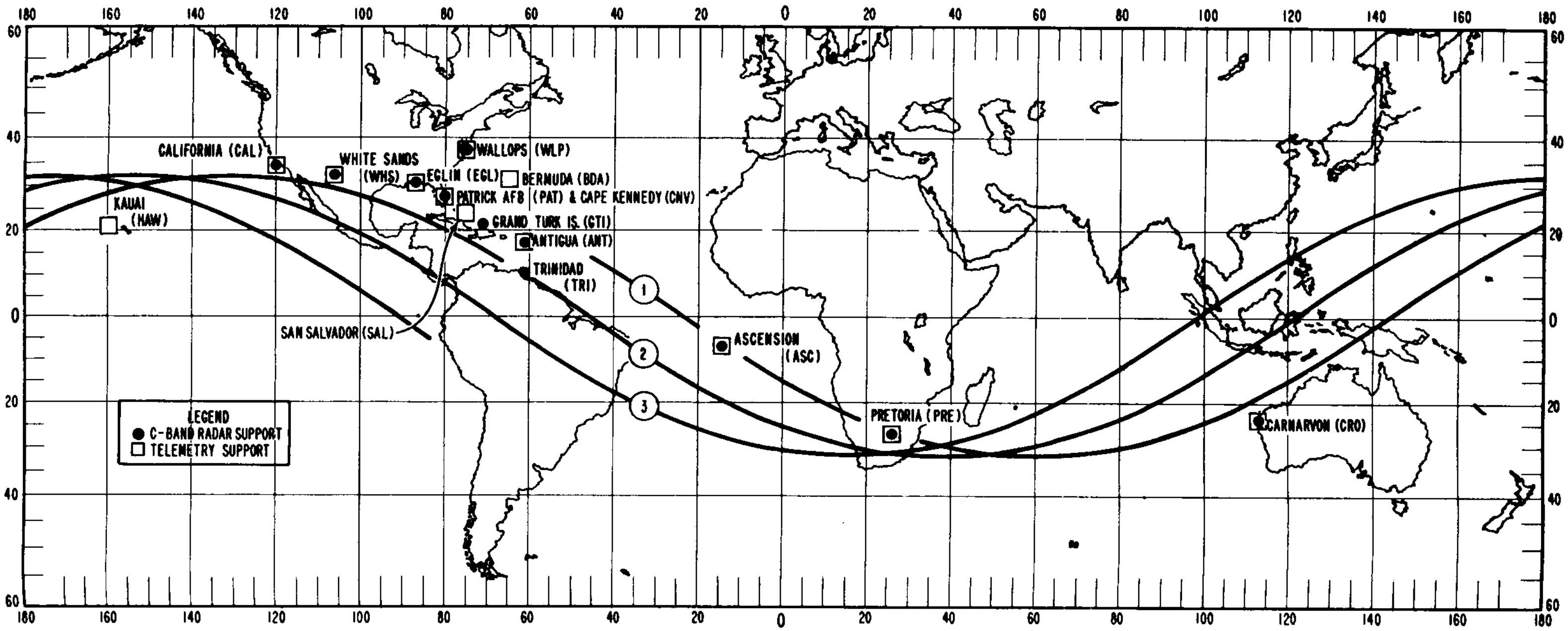


Alphabetical listing of station designators:

ANT	Antigua	EGL	Eglin, Florida	TRI	Trinidad
ASC	Ascension Island	GTI	Grand Turk Island	WLP	Wallops Station, Virginia
BDA	Bermuda	HAW	Kauai, Hawaii	WHS	White Sands, New Mexico
CAL	Point Arguello, California	PAT	Patrick AFB, Florida		
CNV	Cape Kennedy, Florida	PRE	Pretoria, South Africa		
CRO	Carnarvon, Western Australia	SAL	San Salvador Island		

Figure 1. Locations of Stations Providing C-band Radar and Telemetry Support and the Ground Path for First Three Revolutions

1. INTRODUCTION

This report summarizes the performance of the Manned Space Flight Network (MSFN) for the SA-6 mission.

The purpose of this mission was to place in earth orbit a vehicle made up of the second-stage booster, the instrumentation unit, and the boilerplate spacecraft to test the Saturn-Apollo configuration and the structural soundness and aerodynamics of the Apollo spacecraft.

The Manned Space Flight Network, composed of NASA and DOD National Range facilities, was responsible for recording telemetry data and for providing tracking and computer support during the orbital flight and reentry phases. Marshall Space Flight Center, Huntsville, Alabama, has responsibility for the overall R&D program.

The next section of this report briefly describes some of the major premission activities that took place to bring the network up to a state of readiness to support the mission. Following this, performance of each of the major network systems is described, and then brief comments are made regarding the data reduction program.

How the network was arranged for providing telemetry and radar support is shown in figure 1. In addition to this basic arrangement, a number of stations from other networks also were called up for this mission to provide minitrack and optical tracking data to the computing center at Goddard. Information concerning performance of these stations is included in Appendix A. These networks and stations are:

North American Air Defense Command (NORAD) Stations

Moorestown, New Jersey
Laredo, Texas
Navspasur Net
Diyarbekir, Turkey
Trinidad, British West Indies

Space Tracking and Data Acquisition Network (STADAN)

Fort Myers, Florida
Goldstone, California
Johannesburg, South Africa
Lima, Peru
Quito, Ecuador
Santiago, Chile
Woomera, Australia

Smithsonian Astrophysical Observatory (SAO)

Organ Pass, New Mexico
Olifantsfontein, South Africa
Woomera, Australia
San Fernando, Spain
Tokyo, Japan
Naini Tal, India
Arequipa, Peru
Shiraz, Iran
Curacao, Venezuela
Villa Dolores, Argentina
Maui, Hawaii

SAO Moonwatch Team

Pretoria, South Africa
Manila, Philippine Islands
Taipei, Formosa

2. NETWORK SUPPORT PREPARATIONS

2.1 DOCUMENTATION

Documentation for SA-6 by the Manned Flight Operations Division commenced with the writing of the MSF Network Requirements for SA-6, which was completed February 14, 1964. It outlined the requirements placed upon GSFC by Marshall Space Flight Center (MSFC) for all stations required to support SA-6 and provided a basis for writing the Network Support Plan for SA-6 (NSP). The NSP was published on March 31.

Using the NSP as a basis, the NASA-GSFC Network Operations Plan, Saturn 6, dated May 1, 1964, was written to coordinate the support of MSFN, STADAN, SAO, NORAD, and SPADATS networks. One revision, published on May 11, was made to the NOP.

The operations requirements document for DOD support of SA-6 (OR 2460) was submitted to AFMTC on March 16, 1964. From the OR 2460, AFMTC prepared OD 2460, Orbital Tracking and Data Acquisition, Saturn SA-6, dated May 4, 1964.

Instrumentation Support Instructions (ISI's) are issued during mission periods only to correct, modify, or clarify mission support requirements for that mission. During SA-6, 14 such ISI's were issued as follows:

ISI No.	Subject	Document(s) Affected
1	Mission Period Implementation	NOP
	ISI Messages	N/A
2	Summary Message	NOP
3	Telemetry Support	NOP
	TLM Logs	NOP
4	CRF Format	COP-1, Appendix A
5	Operator's Logs	NOP
6	SA-6 Traffic Handling	N/A
7	TLM Tape Annotation	NOP
8	Telemetry Support	ISI No. 3
9	CRF Format	ISI No. 4
10	Data Procedures	OD 2460, NOP
11	Network Countdown	NOP
12	Standby Manning	N/A
13	Network Data Reduction	NOP, OD 2460
14	Verbal Tracking Report	OD 2460

Station M&O supervisors' PLIM and NDR comments indicated that SA-6 documentation was generally adequate; however, earlier receipt of the NSP's and NOP's by the stations is considered desirable.

2.2 SYSTEM READINESS TESTS

2.2.1 DST/BST's

Mission readiness of station equipment was ascertained by conducting detailed system tests (DST's) and brief system tests (BST's) as called for in the Network Support Plan for SA-6. DST/BST's were run on these systems: C-band radars, telemetry, acquisition aids, intercom, teletype, and timing.

The results of these tests were received from all remote stations which participated. Two stations, GYM and TEX, originally scheduled to support SA-6, requested to be relieved because their equipment implementation programs were in process, and their coverage overlapped other stations in the network.

The BST records did not reflect any serious degradation of tracking system efficiency from the time of DST checks. The overall preliminary evaluation of test results did, however, show a total of 39 discrepancies (all marginal) in the timing system. Since this was reported from five of the six participating remote stations, it is indicative of a need for a thorough maintenance check on this system throughout the network.

This condition was reported to all stations via teletype and a maintenance check was strongly recommended.

2.2.2 CADFISS Tests

CADFISS (Computation and Data Flow Integrated Subsystem) tests were conducted by the Goddard computers to prove out the readiness of the computer-related parts of the network to perform their functions accurately.

On launch day, May 28, CADFISS testing consisted of a series of seven network tests that were conducted during the prelaunch count. This series consisted of communications tests, boresight and range target tests, boresight-acquisition aid slave tests, and radar-slew tests.

The first several tests showed that GTI had an Arcas parity error problem and that ASC and PRE had improper slew rates. These malfunctions were corrected, and the final test showed that all equipment was functioning properly.

CADFISS postlaunch testing was also conducted on May 29, 30, and 31. Since stations were released after their last pass prior to the vehicle's phasing off the range, the stations had to be retested prior to their first acquisition of the vehicle as it phased back over the range. No malfunctions were detected during postlaunch tests.

As a result of the CADFISS tests a high level of confidence was established in the capability of the computing system to support the mission.

3. ACQUISITION AID

Acquisition and pointing information was supplied to the C-band radar and telemetry antennas by the acquisition aids at BDA, CRO, HAW, CAL, WHS, and EGL. Tracking was accomplished on 237.8, 249.9, 257.3, and 258.5 mc. Low-elevation angles and multipath limited the use of automatic tracking in the elevation axis to the following:

Rev.	Per Cent	Station	Acq. Aid	Elevation Angle (max.)
Launch	33	WLP	AA 1	3°
1	0	BDA	AGAVE (Coopers Island)	8°
1	0	BDA	AGAVE (Town Hill)	8°
1	1	CRO	AA 1	15°
1	50	CRO	AA 2	15°
1	25	CAL	Retrofit	26°
1	25	WHS	AGAVE	68°
1	0	EGL	AGAVE	61°
3	0	HAW	AGAVE	13°

No major malfunctions were reported. Analysis of system operation is limited because system recorders were not available for this mission on Gemini stations. Reduction of the NDR requirements to one pass per station further limited analysis for this report.

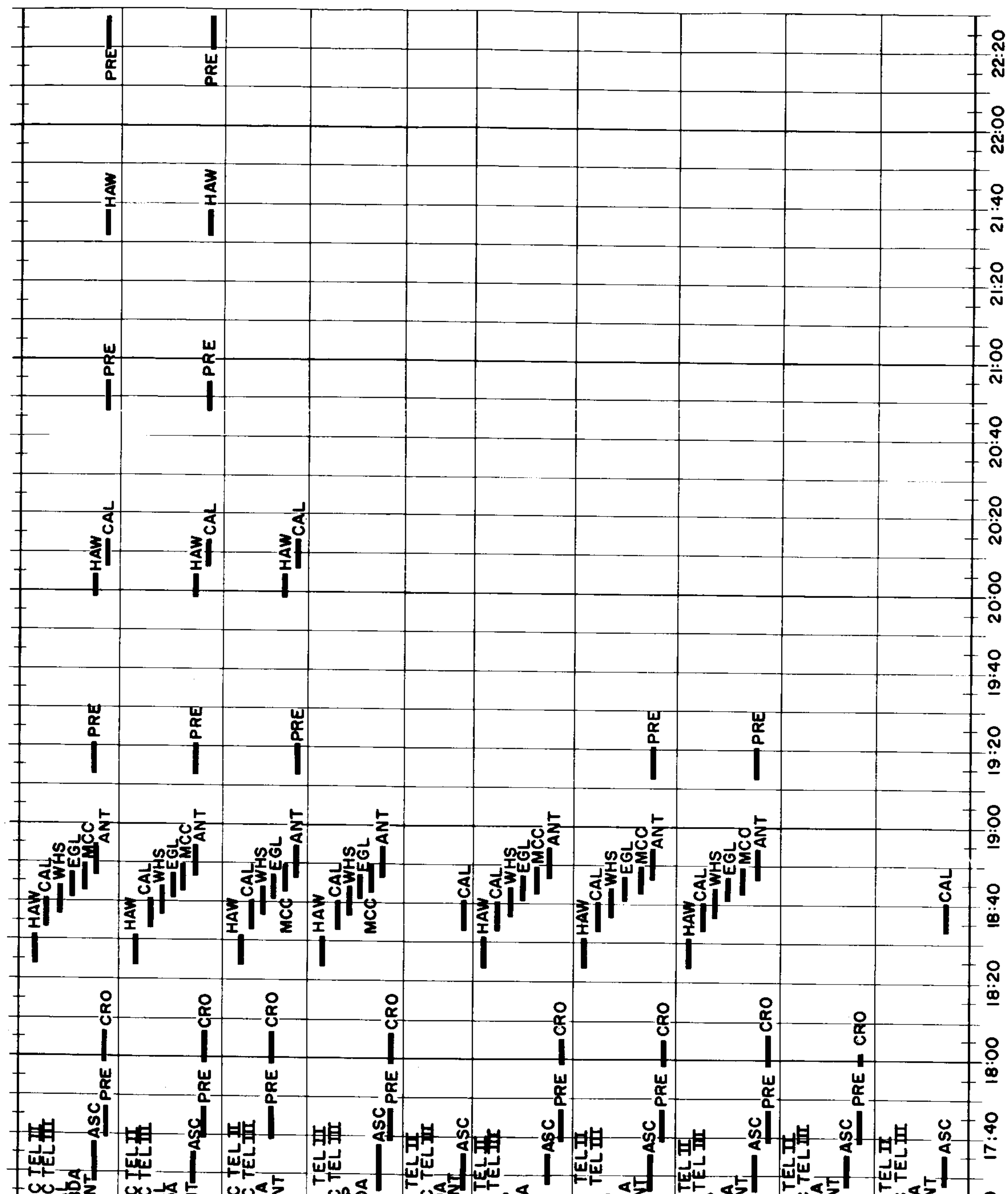


Figure 2. Telemetry Coverage Chart

4. TELEMETRY

The space vehicle carried ten telemetry links. The following network stations were required to record telemetry data to their maximum capability for the life of the on-board transmitter batteries: CNV (MCC Tel II and III), SAL, WLP, BDA, ANT, ASC, PRE, CRO, HAW, CAL, WHS, and EGL.

Telemetry coverage was accomplished as indicated in figure 2 and table 1. The signal strength and quality were generally good, and successful coverage was realized.

All ten telemetry links were good at liftoff and through powered flight. Link P1 dropped out when the spacecraft was over CRO during revolution one, and links F5 and S3 were lost during revolution one. Links F6 and D1 dropped out just after the beginning of revolution two, and links D2 and D3 dropped out toward the end of that revolution. Link C was lost before the third revolution, and links A and B were transmitted until 2200 GMT on May 28, when HAW reported that all telemetry was dead.

Only minor difficulties were encountered during telemetry coverage. Although data was reduced for pass one only, the following comments apply to the entire telemetry effort.

Bermuda

There were two variations to the equipment configuration specified in the Network Operations Plan: (1) the AGC input from link F6 to Sanborn No. 2, pen No. 6, was changed to pen No. 8 when nonlinearities occurred on pen No. 6 and (2) there was no equipment available to record predetected output of RF link 259.7 mc (S3).

The PCM link P1 (253.8 mc) locked up from 17:10:39 through 17:18:50 GMT.

Carnarvon

The 9-minute bit on the serial decimal time did not print out properly on the Sanborns.

Link P1 (253.8 mc) dropped out at 18:01:57 GMT on revolution 1 and remained out for the remainder of the pass.

Fluctuations in signal strength occurred on all links except A, B, and C. These were faster than those normally experienced because of spacecraft tumbling.

Hawaii

The telemetry equipment operated very satisfactorily. Greater signal strength was recorded with the SA-6 configuration than in previous tests.

California

The Gemini equipment was inadequate to record the required number of channels. Some PMR equipment was implemented to accomplish the requirement.

Interference was noted on 258.5, 255.1, 251.5, and 257.3 mc frequencies. This was isolated to a local launch pad prior to pass two.

Excessive multipath was noticed on links 258.5, 255.1, 251.5, and 240.2 mc.

Table 1. Summary of Telemetry Coverage

Link	Freq. (mc)	Transmitter power (watts)	Launch to Range LOS Total (hr:min:sec)	Data Coverage (hr:min:sec)	Data Coverage (%)	Total Range Record Time* (hr:min:sec)
A	237.8	10	5:21:02	1:53:20	35	2:29:25
B	247.3	10	5:21:02	1:49:14	34	2:38:29
C	257.3	10	3:06:26	1:20:15	43	1:58:22
F6	240.2	25	1:47:42	1:09:54	65	1:52:54
F5	249.9	25	0:24:40	0:28:08	84	0:48:27
D1	251.5	10	1:47:42	1:05:54	61	1:37:37
D2	255.1	10	2:13:39	1:15:32	57	1:54:47
D3	258.5	10	2:13:39	1:16:50	58	2:02:13
P1	253.8	5	0:54:57	0:31:48	58	0:53:10
S3	259.7	25	0:28:40	0:22:15	78	0:41:34

*Indicates overlap or redundancy in data recording. (Compare with Data Coverage.)

5. RADAR

Continuous C-band beacon tracking was required from launch through insertion, and maximum C-band beacon/skin track was desired until such time as the beacon expired. To accurately determine orbital parameters of the vehicle, maximum C-band skin track was desired through the first five revolutions, and maximum diversified C-band skin track was required thereafter.

Beacon characteristics were:

	Instrumentation Unit	Apollo Boilerplate
Interrogation frequency	5690 mc	5690 mc
Transponder frequency	5765 mc	5765 mc
Code	Single pulse	Double pulse
Code spacing	N/A	3.5 μsec
Recovery time	100 μsec	100 μsec
Delay	2 μsec	2 μsec
Battery life	20 min	60 min

Radar function recordings, event recordings, operator's logs, and tracking summary messages were required from all tracking stations. Plot board charts were not required.

5.1 PERFORMANCE

The following aids are included in this report to explain radar tracking performance:

(1) Figure 1. Locations of Stations Providing C-Band Radar and Telemetry Support—

This figure (page vi) points out the network configuration for radar and telemetry support and the spacecraft's ground path for revolutions one, two, and three.

(2) Figure 3. Computed Ground Path for Last Three Revolutions.

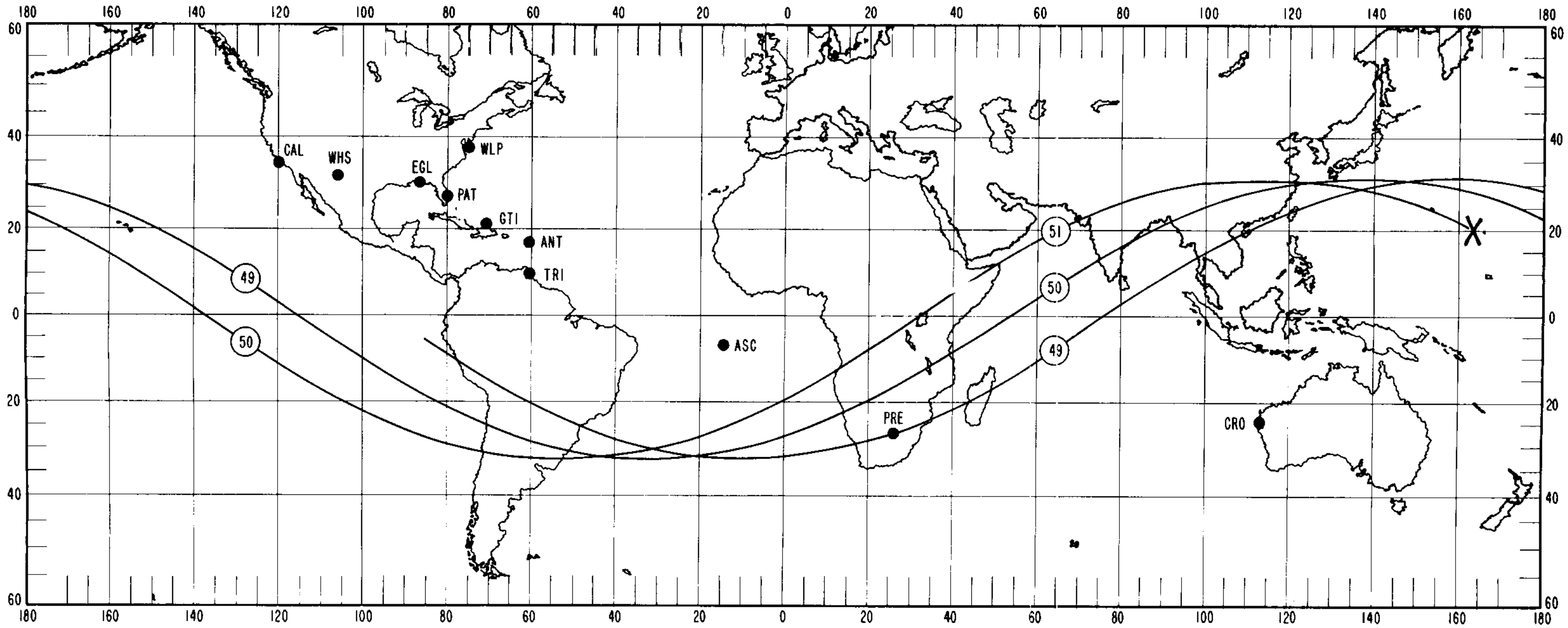


Figure 3. Computer Ground Path for Last Three Revolutions

(3) Table 2. C-Band Radar Coverage Summary—

This table shows the revolutions during which each C-band radar station was expected to see the spacecraft and also which of these stations actually did track as scheduled. The expected coverage was based on the PCA (point of closest approach) being within the practical range of the station. The following ranges were used:

500k yards - CAL and PRE (stations with FPS-16's)

1500k yards - EGL and WHS (stations with high-power FPS-16's)

1500k yards - CRO, PAT, ASC, and ANT (stations with FPQ-6's)

1500k yards - GTI (TPQ-18—mobile FPQ-6)

Horizon - WLP (Spandar)

If the PCA for a station falls outside of the above range limits or the elevation angle is less than three degrees, the station is not shown as being scheduled for that pass.

(4) Table 3. Radar Coverage Details—

This tabulation shows possible station coverage versus auto-track obtained, relative to each station's PCA. Also shown are seconds of data achieved by each station, the range at which various events occurred such as AOS, LOS, PCA, etc., and the means by which each station acquired or attempted to acquire auto-track. Although such a table by no means tells the individual circumstances by which all events occur at each station, it serves to encompass the network as a whole and points out the actual effectiveness of any given station in regard to the network. It must be remembered that all stations do not have the same equipment capabilities. Also, the SA-6 spacecraft was a tumbling vehicle and at times presented smaller areas of reflective surface for skin track than at other times. (It is estimated that the effective cross-sectional areas for the oribiting vehicle varied from 25 square meters nose-on to 98 square meters broadside.) However, as in all random occurrences of this nature, these events should tend to even out.

(5) Figure 4. AGC vs GET on Revolution 27 at CRO.

(6) Figure 5. AGC vs GET on Revolution 42 at CRO—

These two sample AGC plots clearly show the glint and fade effects produced by tumbling. No attempt is made in this report to perform a signature analysis on this data, but in general it might be observed that as much as 30 db of signal fluctuation is present and that the tumble rate is slow (about one tumble per 100 seconds).

Table 2. C-Band Radar Coverage Summary

Rev.	STATION PAT (FPQ-6)	WLP (SPANDAR)	GTI (TPQ-18)	ANT (FPQ-6)	ASC (FPQ-6)	PRE (FPS-16)	CRO (FPQ-6)	CAL (FPS-16)	WHS (HP FPS-16)	EGL (HP FPS-16)
L-1	T		T	T	T	T	T	T	T	T
2	T		S	S	U	T		S	T	
3						S				
4						S				
5										
6										
7					U					
8					U					
9										
10										
11				S			S			
12			S	S			T			S
13	S		S				T			T
14	T	T					T		T	T
15	S	T			U		T	S	T	T
16	T		S	T	U		T	S	S	
17			T							
18										
19						U				
20										
21										
22					U					
23					U					
24										
25										
26			U	S			T			
27			T	S			T			T
28	T	U	S				T		S	T
29	T	T					T	S	T	T
30	T	T	S			S	T	S	T	T
31	T		S	T	U	S	T	S	T	
32	T		T			S				
33						S				
34						S				
35										
36										
37										
38					U					
39					U					
40										
41				S			T			
42			T	S			T			S
43	T		T				T		S	T
44	S	T					T		T	T
45	T	T					T	S	T	S
46	T		T	T	T	T	T	U	T	S
47	T					S				
48						S				
49						T				
50						S				
Total	13T 3S	6T 0S	7T 7S	4T 7S	2T 0S	4T 10S	18T 1S	1T 7S	10T 3S	10T 4S

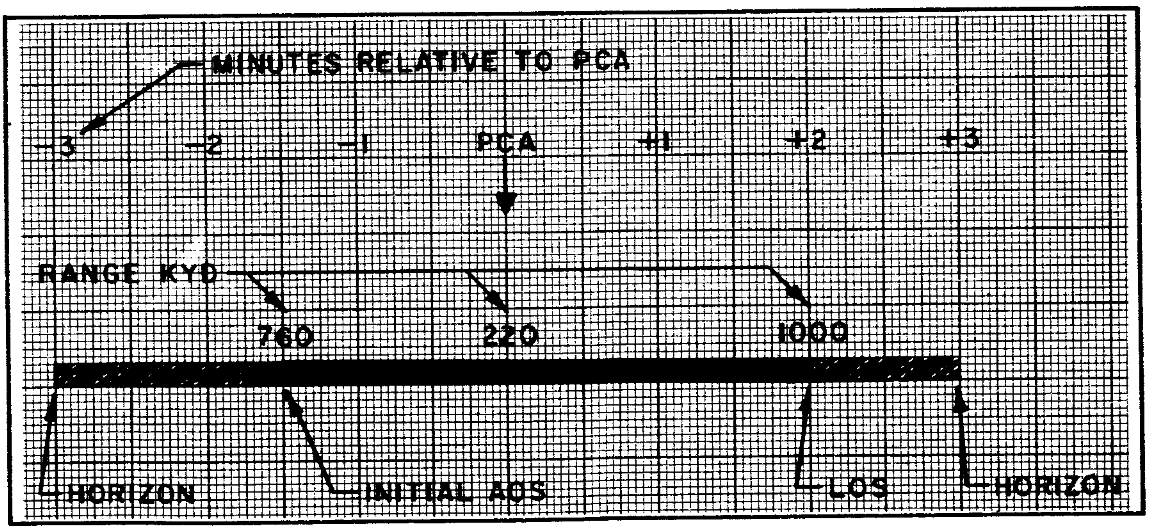
T = Tracked
S = Scheduled (no track obtained)
U = Unscheduled (radar not available for support. S/C was within range.)

Table 3. Radar Coverage Details (page 1 of 7)

LEGEND

Column Headings	Explanation
Station	Designators for stations providing radar support
Acq. Source:	
ARCUS	Cape Kennedy-programmed computer
COMP.	Station computer
P.D.	Pointing data
A.A.	Acquisition aid system
PCA Time, Z	Point of closest approach—that GMT when the spacecraft is closest to the station
Sec. of Data	Number of seconds of data actually reviewed by computing center
EL Angle	The highest elevation angle at which the spacecraft appeared relative to station

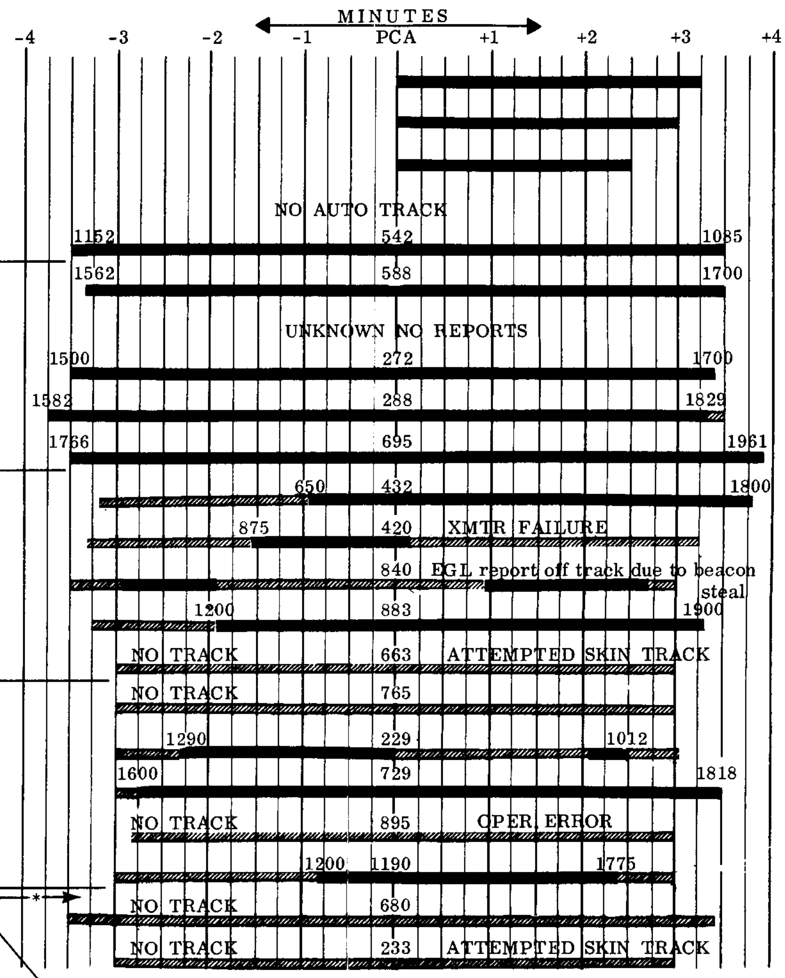
Bar Chart Section:



Horizon	Time of actual line of sight from the indicated radar to the spacecraft at horizon
Initial AOS	Acquisition of signal—initial radar auto-track
LOS	Loss of signal—lost radar auto-track

Table 3. Radar Coverage Details—First Mission Day, May 28 (2 of 7)

Station	Revolution	Acq. Source	PCA Time Z	Sec. of Data	EL Angle
CNV	Launch	-	N/A	536	-
PAT	Launch	-	N/A	440	-
GBI	Launch	-	N/A	499	-
SAL	Launch	-	-	-	-
GTI	-	COMP.	17:14:04	480	-
ANT	1	ARCUS	17:17:51	439	-
TFV	-	-	-	-	-
ASC	1	COMP.	17:31:04	374	51°
PRE	1	COMP.	17:43:32	430	54°
CRO	1	P.D.	18:02:42	439	17°
CAL	1	A.A.	18:36:50	280	26°
WHS	1	P.D.	18:40:24	84	26°
EGL	1	P.D.	18:43:10	160	10°
PAT	1-2	COMP.	18:45:52	320	9°
GTI	2	COMP.	18:48:30	0	15°
ANT	2	A.A.	18:51:16	0	12°
TRI	2	COMP.	18:51:49	167	63°
PRE	2	COMP.	19:16:41	430	16°
CAL	2	A.A.	20:10:00	0	9°
WHS	2	P.D.	20:13:13	180	5°
PRE	3	COMP.	20:50:15	0	17°
PRE	4	COMP.	22:23:45	0	79°



*Evidence indicates that the C-band beacon ceased transmission at this point.

Table 3. Radar Coverage Details—Second Mission Day, May 29 (3 of 7)

Station	Revolution	Acq. Source	PCA Time Z	Sec. of Data	EL Angle
ANT	11	ARCUS, P.D.	09:02:00	0	19°
CRO	11	-	09:47:00	0	9°
GTI	12	COMP.	10:33:40	0	41°
ANT	12	ARCUS	10:35:15	0	12°
CRO	12	P.D.	11:21:58	183	54°
EGL	12	P.D.	12:04:40	0	9°
PAT	12-13	COMP.	12:05:30	0	26°
GTI	13	COMP.	12:06:45	0	10°
CRO	13	P.D.	12:55:24	234	13°
EGL	13	P.D.	13:37:48	154	68°
PAT	13-14	COMP.	13:39:05	315	31°
WLP	13-14	P.D.	13:40:50	186	11°
CRO	14	P.D.	14:29:02	272	13°
WHS	14	P.D.	15:06:42	168	35°
EGL	14	P.D.	15:11:00	103	46°
PAT	14-15	P.D.	15:12:30	0	23°
WLP	14-15	P.D.	15:13:19	233	10°
CRO	15	P.D.	16:02:28	243	39°
CAL	15	P.D.	16:36:45	0	25°
WHS	15	P.D.	16:39:48	156	69°
EGL	15	P.D.	16:44:11	177	57°
PAT	15-16	COMP.	16:45:50	196	74°
GTI	15-16	COMP.	16:48:30	0	23°
ANT	16	COMP.	16:50:45	131	20°
CRO	16	P.D.	17:35:35	287	15°
CAL	16	P.D.	18:09:45	0	24°
WHS	16	P.D.	18:12:45	0	23°
GTI	16-17	P.D.	18:21:15	132	12°

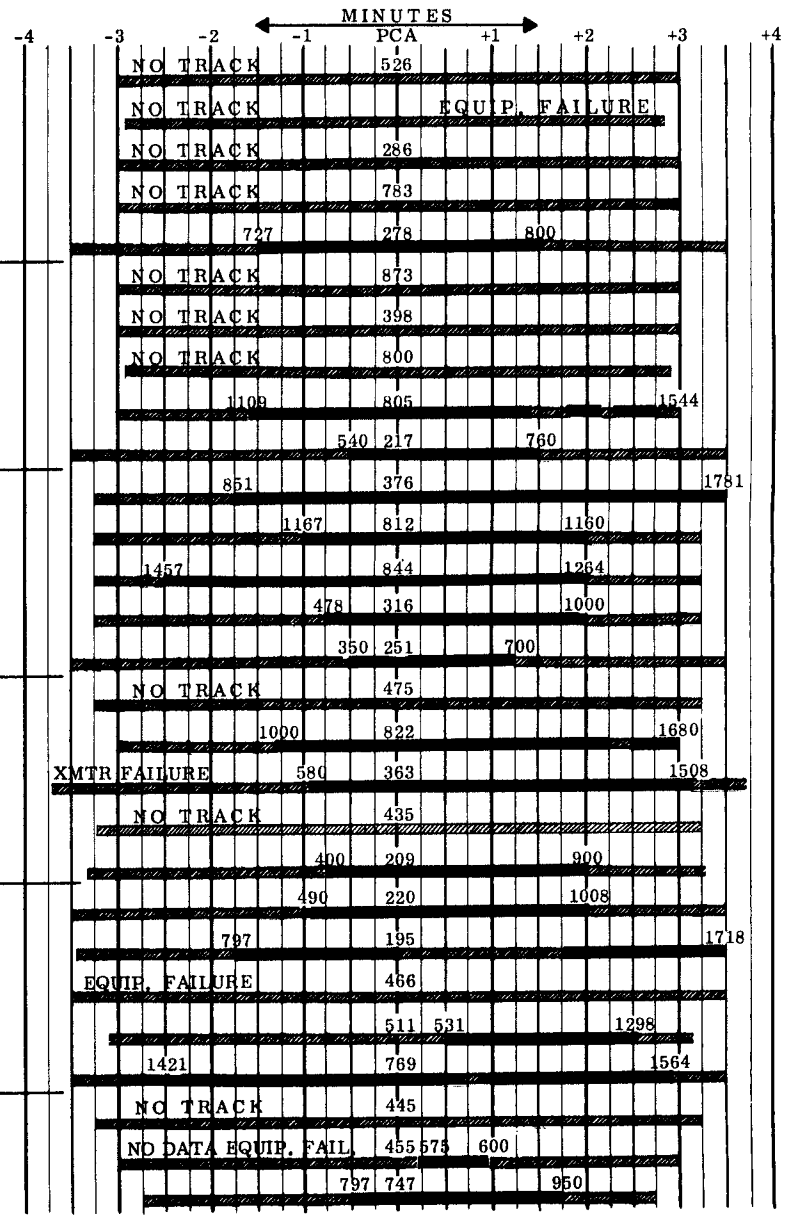


Table 3. Radar Coverage Details—Third Mission Day, May 30 (4 of 7)

Station	Revolution	Acq. Source	PCA Time Z	Sec. of Data	EL Angle
ANT	26	-	08:33:40	0	25°
CRO	26	P.D.	09:19:32	211	9°
GTI	26-27	COMP.	10:04:45	50	55°
ANT	27	-	10:06:13	0	10°
CRO	27	P.D.	10:52:25	330	45°
EGL	27	P.D.	11:35:06	53	10°
PAT	27-28	COMP.	11:36:05	315	30°
GTI	28	COMP.	11:37:45	0	10°
CRO	28	P.D.	12:25:38	210	11°
WHS	28	P.D.	13:03:47	0	8°
EGL	28	P.D.	13:07:50	107	71°
PAT	28-29	COMP.	13:09:12	182	28°
WLP	29	P.D.	13:10:30	336	10°
CRO	29	P.D.	13:59:00	278	11°
CAL	29	-	14:33:10	0	9°
WHS	29	P.D.	14:36:30	174	37°
EGL	29	P.D.	14:40:48	116	44°
PAT	29-30	COMP.	14:42:14	296	21°

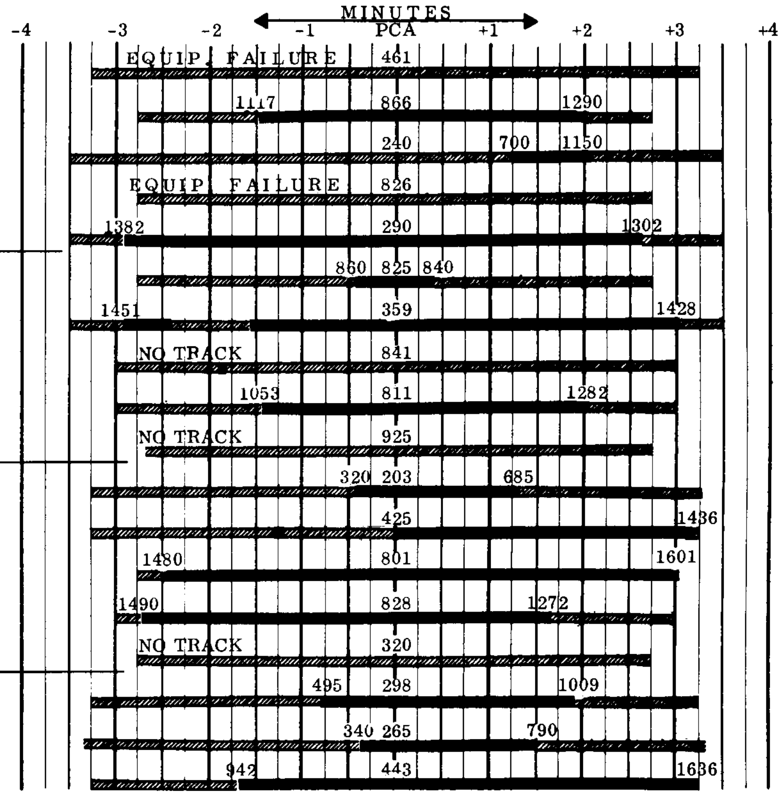


Table 3. Radar Coverage Details—Third Mission Day, May 30 (5 of 7)

Station	Revolution	Acq. Source	PCA Time Z	Sec. of Data	EL Angle
WLP	30	P.D.	14:43:00	350	10°
GTI	30	COMP.	14:43:45	0	5°
PRE	30	COMP.	15:11:30	0	12°
CRO	30	P.D.	15:32:09	339	38°
CAL	30	P.D.	16:06:22	0	23°
WHS	30	P.D.	16:09:15	198	70°
EGL	30	P.D.	16:13:46	133	55°
PAT	30-31	COMP.	16:15:10	338	77°
GTI	30-31	COMP.	16:17:45	0	22°
ANT	31	ARCUS	16:20:30	61	20°
PRE	31	COMP.	16:45:30	0	39°
CRO	31	P.D.	17:04:59	108	12°
CAL	31	P.D.	17:39:00	3	22°
WHS	31	P.D.	17:42:12	174	21°
PAT	31-32	COMP.	17:47:52	120	6°
GTI	31-32	COMP.	17:50:40	194	10°
PRE	32	COMP.	18:18:30	0	13°
PRE	33	COMP.	19:51:45	0	16°
PRE	34	COMP.	21:24:45	0	76°

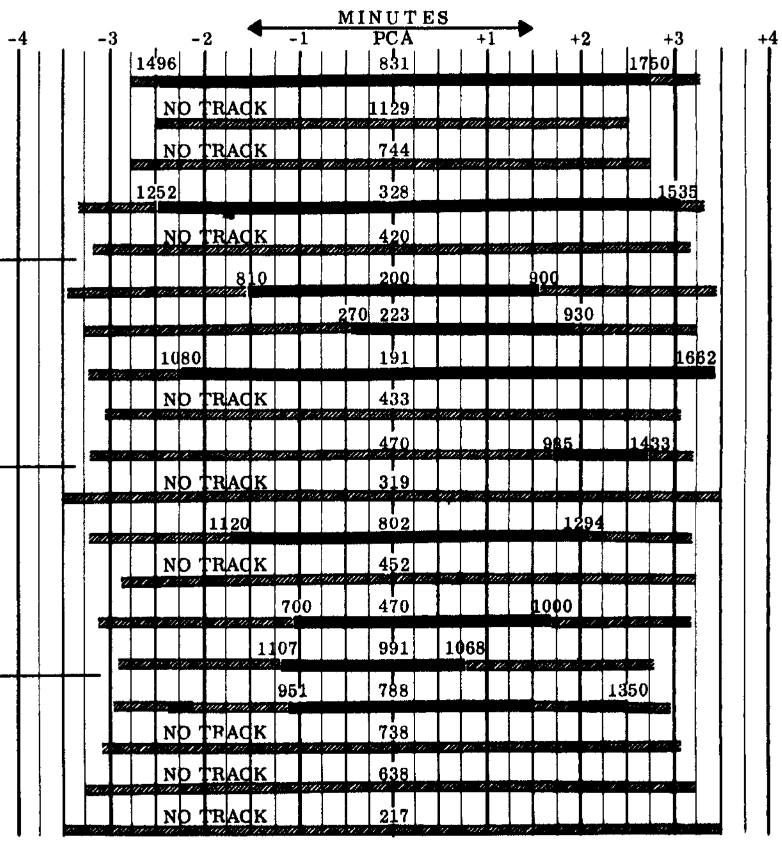


Table 3. Radar Coverage Details—Fourth Mission Day, May 31 (6 of 7)

Station	Revolution	Acq. Source	PCA Time Z	Sec. of Data	EL Angle
ANT	41	P.D.	07:59:30	0	18°
CRO	41	P.D.	08:45:32	175	7°
GTI	42	COMP.	09:30:30	52	42°
ANT	42	ARCUS	09:32:10	0	9°
CRO	42	P.D.	10:17:56	331	43°
EGL	42	P.D.	11:00:30	0	7°
PAT	42-43	COMP.	11:01:30	280	24°
GTI	43	COMP.	11:03:12	62	8°
CRO	43	P.D.	11:50:41	308	9°
WHS	43	P.D.	12:29:00	0	5°
EGL	43	P.D.	12:32:43	105	60°
PAT	43-44	COMP.	12:34:00	0	25°
WLP	44	P.D.	12:35:20	207	8°
CRO	44	P.D.	13:23:36	105	10°
WHS	44	P.D.	14:01:00	180	35°
EGL	44	P.D.	14:05:16	116	41°
PAT	44-45	COMP	14:06:30	315	20°

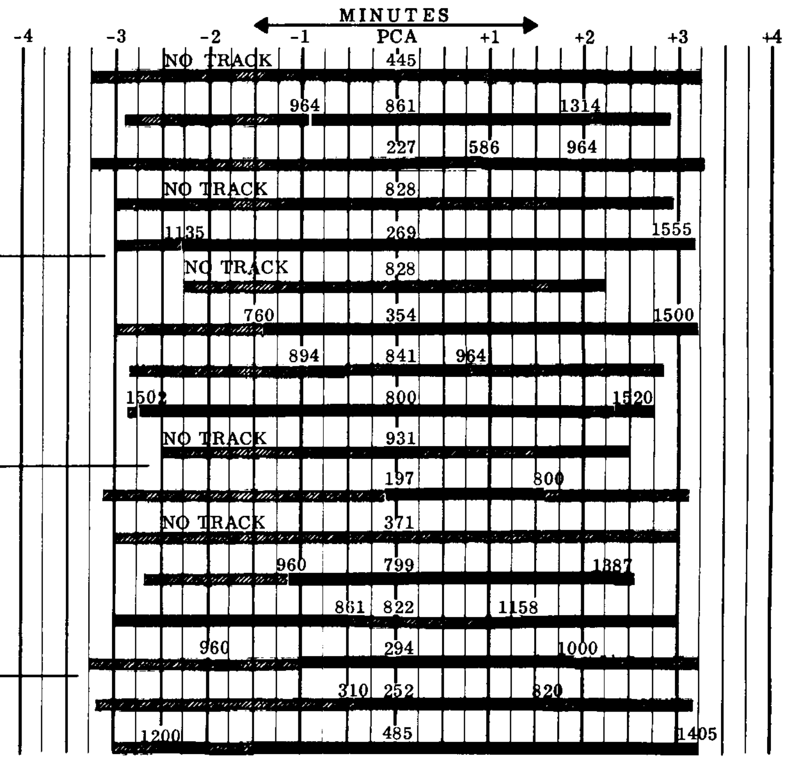
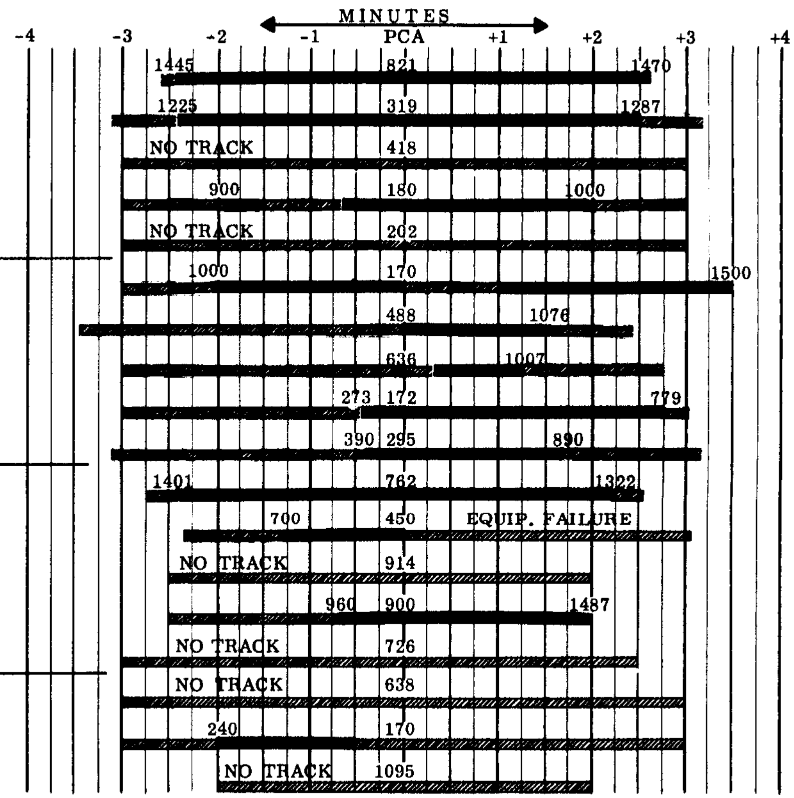


Table 3. Radar Coverage Details—Fourth Mission Day, May 31 (7 of 7)

Station	Revolution	Acq. Source	PCA Time Z	Sec. of Data	EL Angle
WLP	45	P.D.	14:07:22	303	8°
CRO	45	P.D.	14:56:12	302	34°
CAL	45	P.D.	15:30:15	0	22°
WHS	45	P.D.	15:33:15	165	69°
EGL	45	P.D.	15:37:30	0	55°
PAT	45-46	COMP.	15:39:00	215	80°
GTI	46	COMP.	15:42:07	95	20°
ANT	46	ARCUS	15:44:15	60	18°
ASC	46	COMP.	15:57:45	190	75°
PRE	46	COMP.	16:09:05	130	36°
CRO	46	P.D.	16:28:27	280	10°
WHS	46	P.D.	17:05:24	72	19°
EGL	46	P.D.	17:10:00	0	6°
PAT	46-47	COMP.	17:11:30	140	6°
PRE	47	COMP.	17:42:00	0	11°
PRE	48	COMP.	19:14:30	0	13°
PRE	49	COMP.	20:47:00	90	85°
PRE	50	COMP.	22:19:00	0	4°



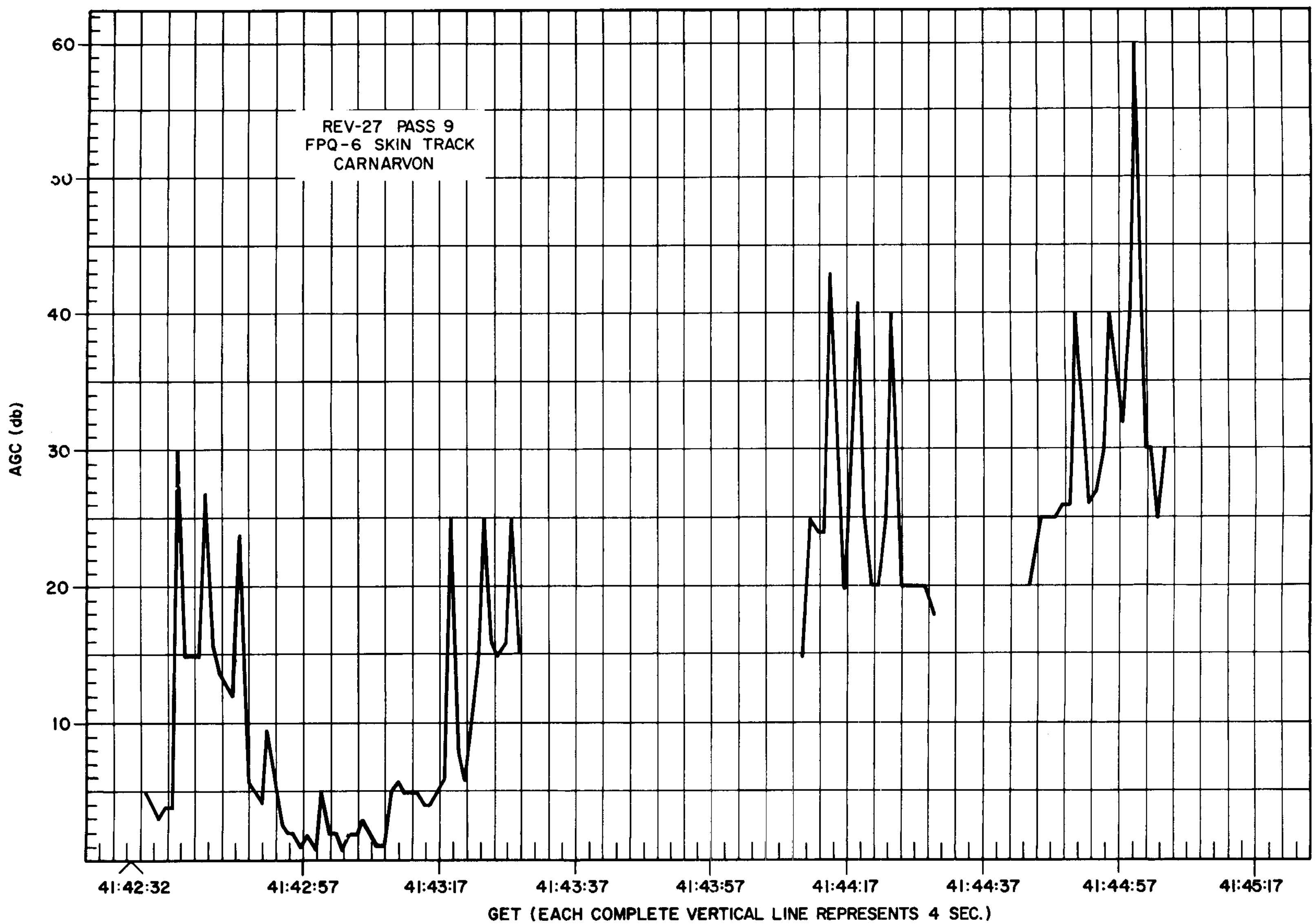


Figure 4. AGC vs GET on Revolution 27 at CRO (1 of 2)

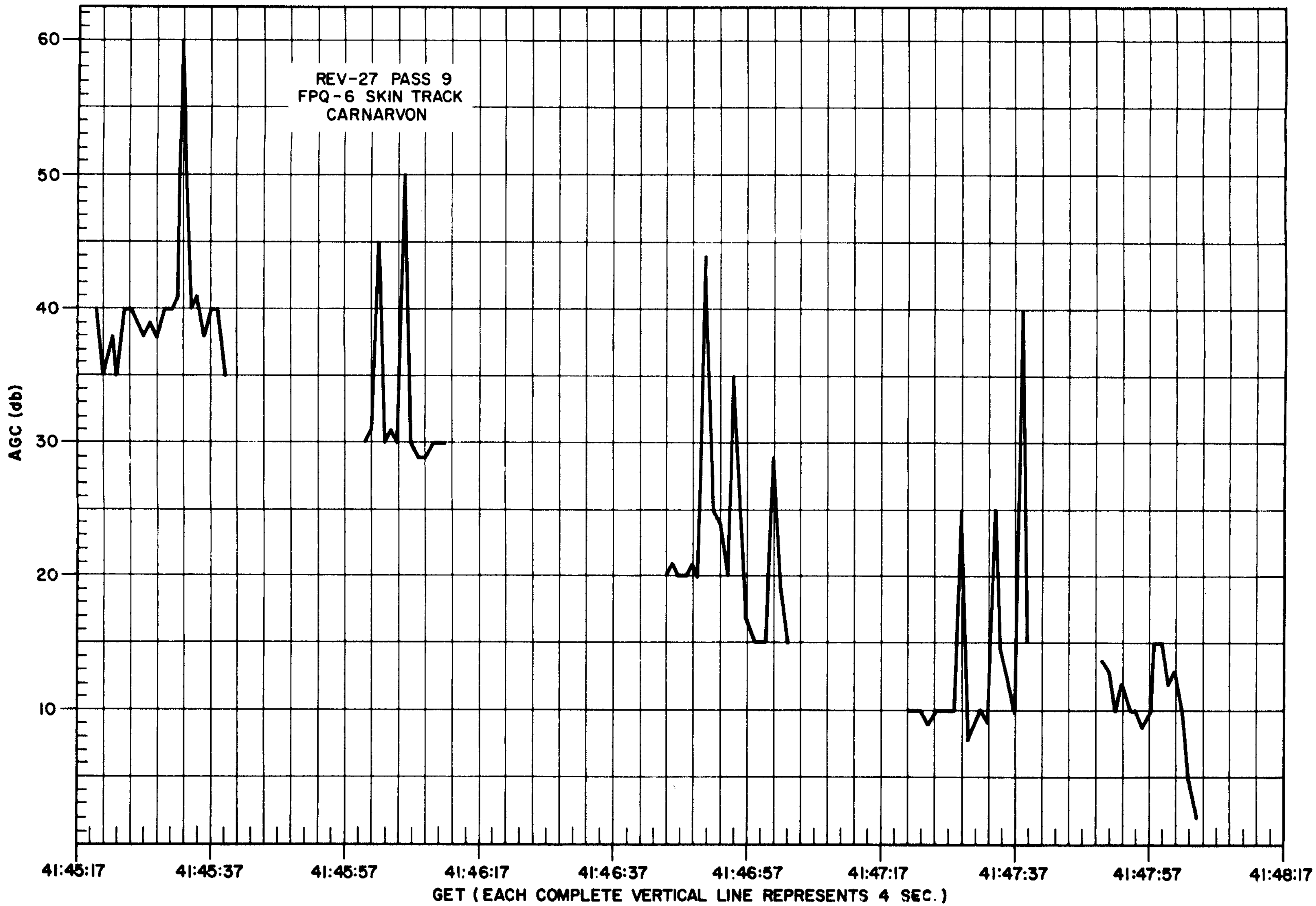


Figure 4. AGC vs GET on Revolution 27 at CRO (2 of 2)

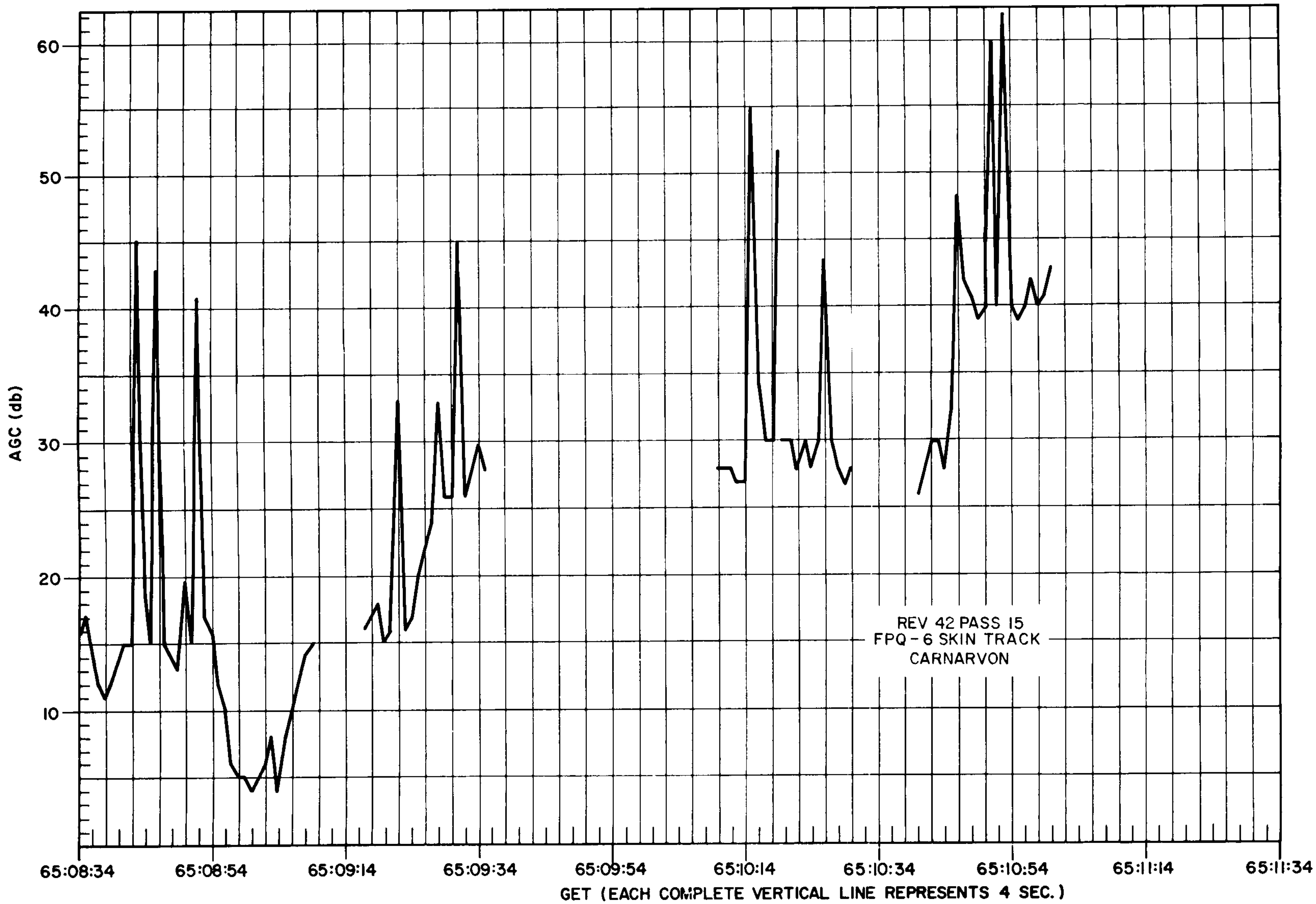


Figure 5. AGC vs GET on Revolution 42 at CRO (1 of 2)

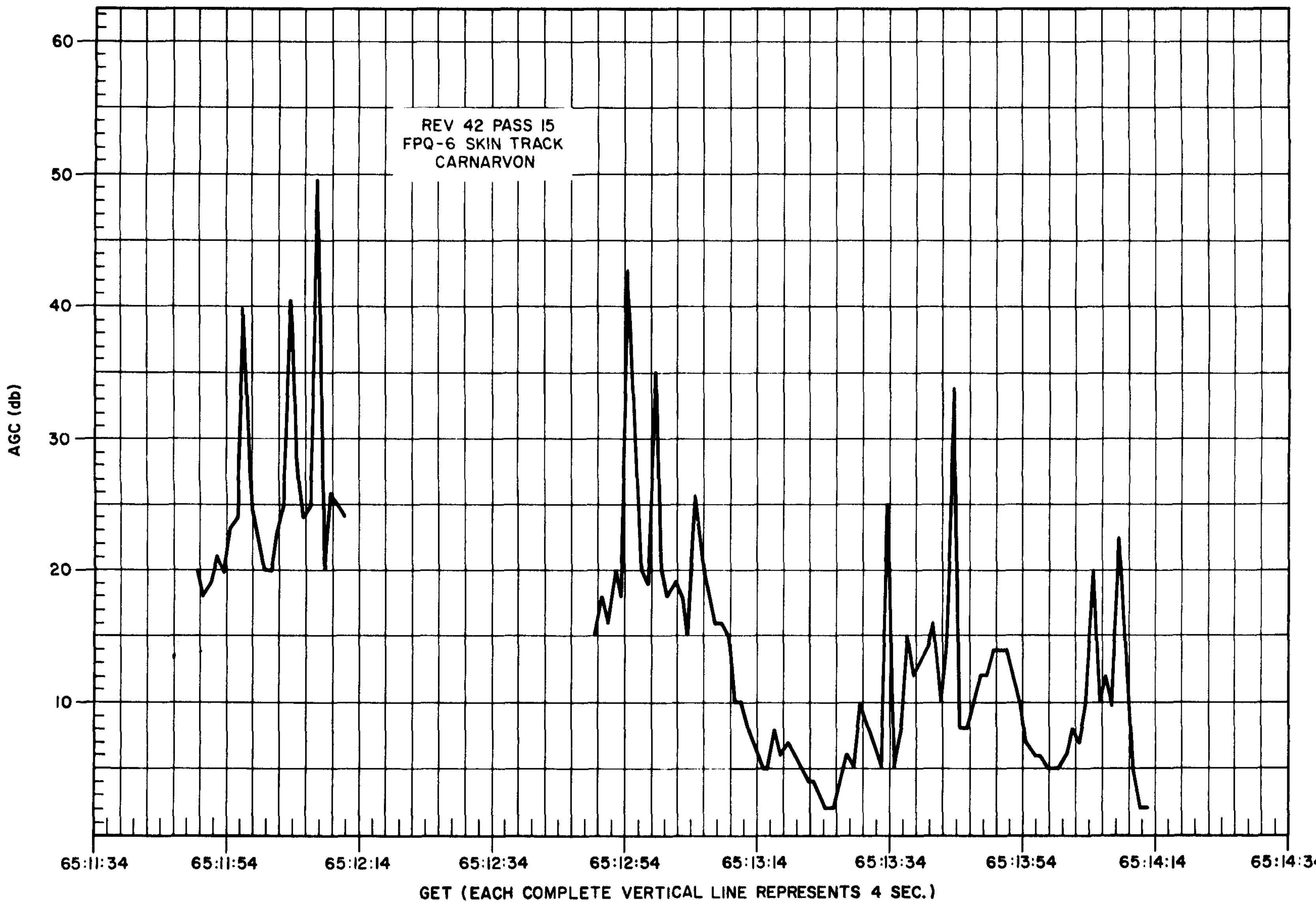


Figure 5. AGC vs GET on Revolution 42 at CRO (2 of 2)

5.1.1 First Mission Day

Powered flight and the initial passes over GTI, ANT, ASC, PRE, and CRO were normal with all stations reporting good beacon track and horizon-to-horizon coverage. CAL radar on the first pass did not obtain auto-track until about 120 seconds after horizon. WHS obtained auto-track about 90 seconds after horizon time and subsequently had a transmitter outage at PCA, causing an interrupted track. EGL, using acquisition aid as a source, acquired the spacecraft as it came over the horizon, but after about 60 seconds of track they reported losing track because of a beacon steal (another radar interrogating the beacon in such a manner as to cause the first radar to lose track).

PAT acquired auto-track about 70 seconds after horizon, using their 7094 computer in a step function as an acquisition source. GTI attempted to skin track the spacecraft at this time, using the PAT radar as a source of pointing information, and although the spacecraft passed within range of the station, no returns were seen and no auto-track was achieved. ANT's attempts to track the beacon at this time were unsuccessful. TRI then tracked the vehicle, but with some interruption of auto-track. PRE, using the 1206 computer as an acquisition source, auto-tracked shortly after horizon time and continuously tracked the vehicle for 430 seconds. CAL failed to auto-track this pass because of an operator error. WHS, using pointing data to acquire the spacecraft, established auto-track two minutes after horizon time and successfully tracked the spacecraft beacon until LOS. This was the last reported beacon track of the mission, and 35 minutes later PRE reported no signal on revolution 3. PRE unsuccessfully attempted to skin track the spacecraft on revolution 4, which ended the first mission day as the spacecraft phased away from those stations capable of radar track.

A review of the activities of the first mission day shows that AOS by various stations was not as quick as anticipated, and that 16 per cent more coverage could have been obtained if unexpected equipment failures and operator errors had not occurred. There were also two instances (GTI and ANT) of track not being obtained on revolution 2 which do not readily explain themselves, since in both instances ranges and angles were such that under normal circumstances auto-track should have been obtained.

5.1.2 Second Mission Day (Revolutions 11 through 17)

During revolution 11 and most of revolution 12, no radar track was obtained from ANT, CRO (radar RED), GTI, and again ANT. In all instances it is felt that elevation angles and ranges would normally permit track. On revolution 12, CRO acquired the spacecraft and reported the pointing data to be 34 seconds in error. EGL on revolution 12 and GBI on revolution 13 attempted track but could not reasonably be expected to acquire the vehicle because of range limitations. However, the PAT radar on revolution 13 did not acquire auto-track even though the range was reasonable. New pointing data was transmitted to the stations, and CRO—after acquiring auto-track on revolution 13—reported that the new pointing data was exact. Revolutions 14 through 17 were successfully tracked by several of the network stations. The last pass of the day was tracked by GTI (revolution 17), which incidentally was the first successful auto-track obtained by GTI since the launch phase.

5.1.3 Third Mission Day (Revolutions 26 through 34)

The skin-track phase of the mission continued with several trends being evident: (1) CAL and PRE FPS-16's do not have the capability to skin track a target such as the SA-6 vehicle, and (2) GTI radar was not getting the track other comparable radars were. This second trend also appeared, but to a considerably less degree, at the PAT radars during the first and second mission days. It should be noted that CRO during the same periods, using comparable equipment without paramps, continuously obtained early acquisition and long tracks.

5.1.4 Fourth Mission Day (Revolutions 41 through 50)

Coverage performance for the final mission day was similar to previous days with about the same trends evident.

On the final pass above any radar station, PRE obtained 90 seconds of auto-track, which proved to be the last radar contact obtained. GTI again had difficulty obtaining and holding track. EGL and PAT on occasions missed passes which both were expected to track, but since the vehicle was not stabilized and was obviously tumbling, missed passes could be expected.

5.2 CONCLUSIONS

A number of specific conclusions can be drawn from the radar tracking performance on this mission:

(1) Slightly better horizon pickup during the beacon phase was anticipated, even though the spacecraft was tumbling at that time.

(2) GTI did not seem to be able to acquire the spacecraft with any degree of consistency.

(3) On the second mission day, it took too long for the network to start providing data. This can be partly attributed to the pointing data being off some 34 seconds at that time; however, it is felt that proper use of pointing data could have readily overcome this contingency.

(4) The procedure of sending stations two different sets of pointing data from two different sources, as was the case in the early part of this mission, is questioned. Aside from the point it raises in regard to duplication of efforts, it could cause confusion on the part of the radar operators at the stations.

(5) Stations using GSFC-generated pointing data and beam-intercept techniques more consistently achieved auto-track and earlier acquisition than those stations using computer-driven acquisition programs.

Several efforts were exemplary:

(1) CRO tracked 18 out of 19 possible passes, missing only one pass, and that was attributable to an equipment failure.

(2) CAL and PRE, despite their equipment limitations, continued to attempt acquisition during the entire mission. This persistence paid off on revolution 49, when PRE was able to provide 90 seconds of track. This was the last radar station to track the spacecraft.

(3) Station estimates of tumble were expeditiously forwarded to computer personnel, which provided an excellent input in resolving the decay characteristic of the spacecraft.

Although radar data was not always obtained when expected, the data provided by the radar network was sufficient to accurately determine orbital parameters and was of excellent quality. This final conclusion will be substantiated by the information found in section 7, computing system performance.

6. REENTRY CONTINGENCY TRACKING

During the latter portion of the mission it became apparent that use of the reentry contingency plan would be required since the spacecraft would reenter after a period of very low radar coverage. It was felt that ground stations tracking the 136.650-mc Minitrack beacon could materially assist in determination of the reentry area and time.

GYM, CRO, and CTN attempted to temporarily convert their 220-260-mc equipment to 136-mc operation. The attempt failed, however, primarily because of the narrow-band characteristics of the antenna system, the hybrid rings, and the non-availability of low-noise preamplifiers for that frequency range.

Stations at South Point (SNT), Hawaii; Darwin, Australia; Ascension Island; and Pt. Arguello, California, were called up and successfully tracked the spacecraft from the 44th through the 50th revolution. The failure of any station to acquire and track the beacon after the 50th revolution helped verify that reentry had occurred.

Listed below is 136-mc Minitrack beacon tracking summary data:

Station	Rev.	AOS	PCA	LOS
SNT	44	-	31/13:49:00	-
CAL	44	31/13:55:00	31/13:58:50	31/14:02:27
SNT	45	-	31/15:21:30	-
CAL	45	31/15:27:39	31/15:30:27	31/15:33:32
ASC	46	31/15:41:20	31/15:57:50	31/16:01:30
CRO	46	31/16:31:10	31/16:33:50	31/16:36:21
CAL	46	31/16:59:45	31/17:02:34	31/17:05:36
ASC	47	31/17:28:00	31/17:29:13	31/17:32:30
CAL	47	31/18:32:11	31/18:34:35	31/18:36:15
SNT	49	31/21:30:05	31/21:32:26	31/21:35:25
SNT	50	31/23:01:12	31/23:04:00	31/23:06:51

7. COMPUTING CENTER

The Goddard computing center provided support in these general areas:

(1) During the countdown, the computing system was used for CADFISS tests with the C-band radars. Standard data flow tests, both high and low speed, were conducted.

(2) During powered flight, the computing system received launch trajectory data from ETR and BDA via the launch monitor subsystem, computed the trajectory, and displayed the resulting parameters at MCC on the various required plot boards and consoles.

(3) During orbital flight, the system continuously processed data received from the tracking devices. The computer output data was used to drive the flight control displays at MCC. Acquisition messages were generated for participating radars.

In addition to these activities, the computing center also provided Marshall Space Flight Center with pertinent real-time and near real-time data and kept NASA Headquarters apprised of mission progress on a regular basis.

7.1 PERFORMANCE

A summary of the radar tracking data received during the mission by the GSFC computing center is listed in table 4. Included in the table are the stations, the GMT time of the first and last valid observation, the total number of valid observations, and the number of valid observations less than and greater than 3 degrees. A frame of data consists of range, azimuth, and elevation along with a time tag. This data is received at the computers via low-speed teletype (60 words per minute), one frame every six seconds while the spacecraft is within tracking range of a station. With each frame of data, the station includes a bit indicating whether the data is valid auto-track; hence the definition of valid frames of data. Also shown in the table is the quality of the data, where root mean square (RMS) errors on the measured quantities of range, azimuth, and elevation are tabulated. The number of observations received are not necessarily the same as shown in this summary. Some of the obviously bad data points were removed and in specific cases when the radar was in the second range interval the data was not included. RMS errors were calculated by minimizing the difference between theoretical mathematical quantities established by integrating the total force equations and the measured values of range, azimuth, and elevation. Included in the RMS calculations are noise levels, instrumentation bias, mathematical model errors, and atmospheric refraction errors. Since each station was analyzed separately, the station geodetic error is eliminated.

Table 4. Radar Data Received by Computing Center and RMS Values of Data (1 of 3)

First Mission Day, May 28

STATION and REV.	VALID OBSERVATIONS						RMS ERRORS		
	First Received GMT	Last Received GMT	Total	<3°	>3°	Used	Range (yds)	Azimuth (mils)	Elevation (mils)
GTI 1	17:10:54	17:18:36	78	6	67	6	3.0	0.1	0.2
ANT 1	17:18:42	17:21:18	27	8	19	15	8.0	0.1	0.2
*ASC 1	17:30:30	17:34:42	41	1	40	12	21.0	0.2	0.7
**PRE 1	17:40:06	17:46:54	69	7	62	-	-	-	-
*PRE 1	17:40:54	17:46:54	59	7	52	50	8.0	0.2	0.5
CRO 1	17:59:24	18:06:36	73	14	59	50	10.0	0.1	0.2
CAL 1	18:36:06	18:40:42	47	9	30	30	9.0	0.2	0.2
WHS 1	18:39:24	18:39:54	6	0	6	6	14.0	0.2	0.1
EGL 1	18:41:24	18:46:54	56	17	11	4	1.0	0.2	0.2
PAT 1	18:44:18	18:49:00	48	10	35	32	7.0	0.1	0.3
*PRE 2	19:15:06	19:20:12	51	7	44	43	13.0	0.1	0.4
WHS 2	20:12:42	20:15:36	30	12	18	18	5.0	0.1	0.1

Second Mission Day, May 29

STATION and REV.	First Received GMT	Last Received GMT	Total	<3°	>3°	Used	Range (yds)	Azimuth (mils)	Elevation (mils)
CRO 12	11:21:06	11:23:30	25	0	25	24	6.0	0.1	3.0
CRO 13	12:53:48	12:58:12	45	1	39	38	14.0	0.2	1.1
EGL 13	13:36:48	13:39:18	26	0	26	26	9.0	0.3	0.6
PAT 13	13:37:36	13:42:30	50	3	40	33	7.0	0.2	0.2
WLP 13	13:40:00	13:42:42	27	0	27	27	29.0	0.2	0.2
CRO 14	14:26:42	14:31:00	44	0	44	44	9.0	0.1	0.8
WHS 14	15:06:06	15:08:42	27	0	27	26	13.0	0.4	0.8
EGL 14	15:10:36	15:12:24	19	0	19	18	8.0	0.6	0.6
WLP 15	15:12:00	15:16:24	45	6	37	37	19.0	0.4	0.2
CRO 15	16:01:36	16:05:36	41	0	41	41	8.0	0.2	0.7
WHS 15	16:39:06	16:41:36	26	0	26	25	13.0	0.3	1.0
EGL 15	16:43:18	16:46:12	30	0	30	28	9.0	0.4	0.9
PAT 16	16:44:18	16:49:06	49	1	20	-	-	-	-
*PAT 16	16:44:23	16:48:53	46	2	20	18	107.0	0.1	0.4
ANT 16	16:51:30	16:53:06	17	0	11	10	14.0	0.1	0.3
*ANT 16	16:51:07	17:53:07	21	0	18	-	-	-	-
CRO 16	17:33:12	17:38:30	54	3	44	44	10.0	0.2	0.4
WHS 16	18:13:36	18:13:36	1	0	1	-	-	-	-

*Retransmittal
**Illegal Ones in Messages

Table 4. Radar Data Received by Computing Center and RMS Values of Data (2 of 3)

Third Mission Day, May 30

STATION and REV.	VALID OBSERVATIONS						RMS ERRORS		
	First Received GMT	Last Received GMT	Total	<3°	>3°	Used	Range (yds)	Azimuth (mils)	Elevation (mils)
CRO 26	9:18:12	9:21:36	35	0	35	28	9.0	0.1	0.2
CRO 27	10:49:36	10:55:06	56	0	56	50	17.0	0.3	0.8
PAT 28	11:34:30	11:38:48	44	0	44	38	9.0	0.3	0.4
EGL 27	11:34:42	11:35:24	8	0	8	8	16.0	1.3	1.6
CRO 28	12:24:18	12:27:42	35	0	35	34	7.0	0.2	0.3
EGL 28	13:07:24	13:09:12	19	0	19	17	10.0	0.4	0.5
WLP 29	13:08:00	13:13:36	57	12	45	45	29.0	0.2	0.3
PAT 29	13:09:18	13:12:12	30	3	22	16	13.0	0.3	0.6
CRO 29	13:56:24	14:01:00	47	1	46	45	8.0	0.1	0.2
WHS 29	14:35:42	14:38:30	29	0	29	29	8.0	0.3	0.4
EGL 29	14:40:24	14:42:24	21	0	21	20	9.0	0.3	0.5
WLP 30	14:40:30	14:46:12	58	14	44	45	12.0	0.3	0.2
PAT 30	14:40:42	14:45:12	46	3	39	33	36.0	1.4	1.9
CRO 30	15:29:42	15:35:18	57	2	55	50	13.0	0.2	0.6
WHS 30	16:07:42	16:10:54	33	0	33	32	7.0	0.3	0.4
PAT 31	16:13:06	16:18:24	55	3	37	28	9.0	0.2	0.4
EGL 30	16:13:24	16:15:36	23	0	23	23	8.0	0.3	0.5
CRO 31	17:03:18	17:07:06	39	0	39	39	10.0	0.2	0.2
WHS 31	17:41:06	17:43:54	39	6	39	29	8.0	0.6	0.8
PAT 32	17:47:18	17:48:30	13	0	13	13	6.0	0.2	0.2
GTI 32	17:50:06	17:51:54	19	0	19	19	18.0	0.3	0.5

Table 4. Radar Data Received by Computing Center and RMS Values of Data (3 of 3)

Fourth Mission Day, May 31

STATION and REV.	VALID OBSERVATIONS						RMS ERRORS		
	First Received GMT	Last Received GMT	Total	<3°	>3°	Used	Range (yds)	Azimuth (mils)	Elevation (mils)
CRO 41	8:43:24	8:47:30	43	3	30	29	7.0	0.1	0.3
GTI 42	9:32:00	9:32:24	5	0	5	5	7.0	1.3	0.3
CRO 42	10:15:42	10:21:12	56	6	50	50	12.0	0.2	0.8
PAT 43	11:00:18	11:04:48	46	2	39	28	54.0	2.0	2.1
CRO 43	11:48:06	11:53:38	55	10	43	43	8.0	0.2	0.3
EGL 43	12:32:36	12:34:18	18	0	18	17	6.0	0.3	0.4
WLP 44	12:32:48	12:37:36	49	5	32	32	15.0	0.4	0.3
*GTI 43	11:03:17	11:03:59	8	0	8	-	-	-	-
CRO 44	13:23:06	13:24:54	19	0	19	19	5.0	0.1	0.1
WHS 44	13:59:06	14:02:54	39	0	30	28	7.0	0.5	0.4
EGL 44	14:04:48	14:06:42	20	0	20	20	7.0	0.3	0.3
WLP 45	14:05:00	14:10:00	51	12	39	38	10.0	0.2	0.3
CRO 45	14:53:48	14:58:48	51	1	50	49	13.0	0.2	0.7
WHS 45	15:32:36	15:35:12	27	0	27	26	8.0	0.3	0.3
PAT 46	15:37:06	15:42:00	50	4	35	24	11.0	0.2	0.4
GTI 46	15:42:11	15:43:35	15	0	15	14	10.0	0.2	0.2
CRO 46	16:26:06	16:31:00	50	7	43	43	8.0	0.2	0.3
WHS 46	17:07:18	17:05:24	12	0	12	12	8.0	0.3	0.5
PAT 47	17:11:06	17:13:24	24	10	12	9	8.0	0.8	2.1
PRE 49	20:45:24	20:46:18	9	0	8	7	68.0	4.0	2.5

*Retransmitted

7.1.1 Launch Phase

Launch time was 17:07:00.1 GMT, May 28, 1964; launch azimuth was 105 degrees. The ETR Range Safety 7094 Computer provided input to the Goddard computers during the launch phase. Data source selection was made from among four available sources: Azusa, Mistram, FPQ-6, and FPS-16.

In the first 60 seconds of track the data source alternated between FPS-16 and Azusa. Azusa had solid track for the next 90 seconds which included second stage cutoff. Within the first 150 seconds of track, the noise level was very low but the flight path angle showed deviations of ±0.3 degree from nominal. The Mistram system first acquired track at 328 seconds. It was not selected as the data source after 574 seconds. The Azusa system was not selected after 412 seconds. The FPQ-6 radar was the selected data source from 574 seconds until second stage cutoff plus 20 seconds. The FPQ-6 data had a noise level of approximately 1 degree in flight path angle. The first 10 seconds of free flight data following second stage cutoff showed oscillations of 75 ft/sec in velocity.

Midway in the launch the vehicle appeared about five miles low in altitude, but guidance corrected this excursion by the time of insertion. This excursion resulted from a shutdown of a first stage engine 23 seconds ahead of schedule.

Manual termination of the launch computing phase and entry into the orbital computations phase was made at 17:18:00 GMT—one second earlier than predicted—with FPQ-6 as the selected data source. Insertion values are shown in table 5.

Table 5. Insertion Values

Definition	Value
Epoch time	17:17:25.3 GMT
Height above oblate earth	598508 feet
Inertial velocity	25630.4 ft/sec
Inertial flight path	+0.0819 degree
Geodetic latitude	21.972 degrees N
Longitude	-61.462 degrees W
Azimuth angle	113.68 degrees
IV stage cutoff	625.2 seconds
Weight	37,000 lbs, ±300 lbs
Inclination	31.8 degrees
Period	88.61 min
Perigee	98.8 nm
Apogee	122 nm
Eccentricity	0.0042

7.1.2 Orbital and Reentry Phases

The FPQ-6 radar was used as the data source for the orbit confirmation phase. The orbit was readily confirmed and no difficulty was encountered in refining the trajectory throughout the mission.

Tracking data from the network during the C-band beacon lifetime was excellent. Figure 1, page vi, shows the ground track for the first three revolutions.

The last live beacon track was received from White Sands at 20:15 GMT. Pretoria reported no C-band beacon return at 22:30 GMT. Real-time computing support at GSFC continued from liftoff at 17:07 GMT to 22:40 GMT on launch day when the vehicle phased off the range.

On May 29, at 09:45 GMT, Goddard resumed the real-time computing operation in the skin track mode. Again the skin track radar data was excellent. The vehicle phased off the network at about 19:00 GMT, and the computing center terminated the real-time tracking mode. During these gaps in the radar network coverage, the STADAN network provided direction cosine data which was processed by the Data Systems Division. For the first time the computing center also used the Minitrack data in the real-time system by mixing it with the radar data.

On May 30, at 09:50 GMT, Goddard again resumed the real-time computing operation in the skin track mode. Toward the end of the operation both the "A" and "B" computers were lost and the "C" computer had to be used to generate acquisition data. Because of the computer malfunctions, real-time operation had to be terminated at about 16:00 GMT.

On May 31, the final day of the mission, the real-time computing mode was resumed at 09:55 GMT. The skin tracking data was excellent while there was radar coverage. At 20:46 GMT, the last radar contact was received from Pretoria, South Africa. The last two Minitrack returns came from Johannesburg, South Africa, at 20:46 GMT and Santiago, Chile, at 23:28 GMT.

Reentry occurred in the Pacific, between Japan and Canton Island, at approximately 00:31 GMT on June 1. The calculated splash point was:

22.13 degrees N latitude

162.29 degrees E longitude

SA-6 had a lifetime of 79 hours and 24 minutes, or 50.4 revolutions. Figure 3, page 10, shows the ground track of the last three revolutions of the flight.

To show orbital decay, the osculating orbital elements are listed below:

Date	Time-GMT (hrs:min)	Apogee (nm)	Perigee (nm)	Period (min)
5/28	18:06	122	98.8	88.61
5/28	20:13	121.5	97.8	88.58
5/29	16:40	116.1	95.5	88.39
5/30	15:32	107.2	91.4	88.19
5/31	17:05	86.4	78.8	87.61
5/31	23:30	70.1	66.1	86.98

7.2 CONCLUSIONS

This was the second time the computing center had tracked an orbiting vehicle through its lifetime from liftoff to reentry without a retrofire maneuver—the first was the first Gemini mission (GT-1). It is found that the exercise continues to be a learning process. The problems of tracking and orbit determination in the lower atmosphere are becoming better defined.

On the basis of the experience gained in this exercise, the following conclusions were made:

(1) The use of a real-time tracking computing mode while skin tracking a space vehicle is no longer an experiment but a proven technique.

(2) The capability of computing and providing timely acquisition data accurate enough to permit even FPQ-6 radars (beamwidth 0.4 degree) to acquire an orbiting vehicle in the skin track mode without the use of acquisition aids is now a proven technique.

(3) There are too many extended gaps in the skin track radar network. An FPQ-6 at Hawaii and Antofagasta, Chile, would permit sufficient coverage for adequate tracking support for any similar future missions.

(4) It is necessary to collect more data in the lower atmosphere to refine the atmospheric model in this region.

8. GROUND COMMUNICATIONS

The ground communications network arrangement for the Manned Space Flight Network is shown in figure 6.

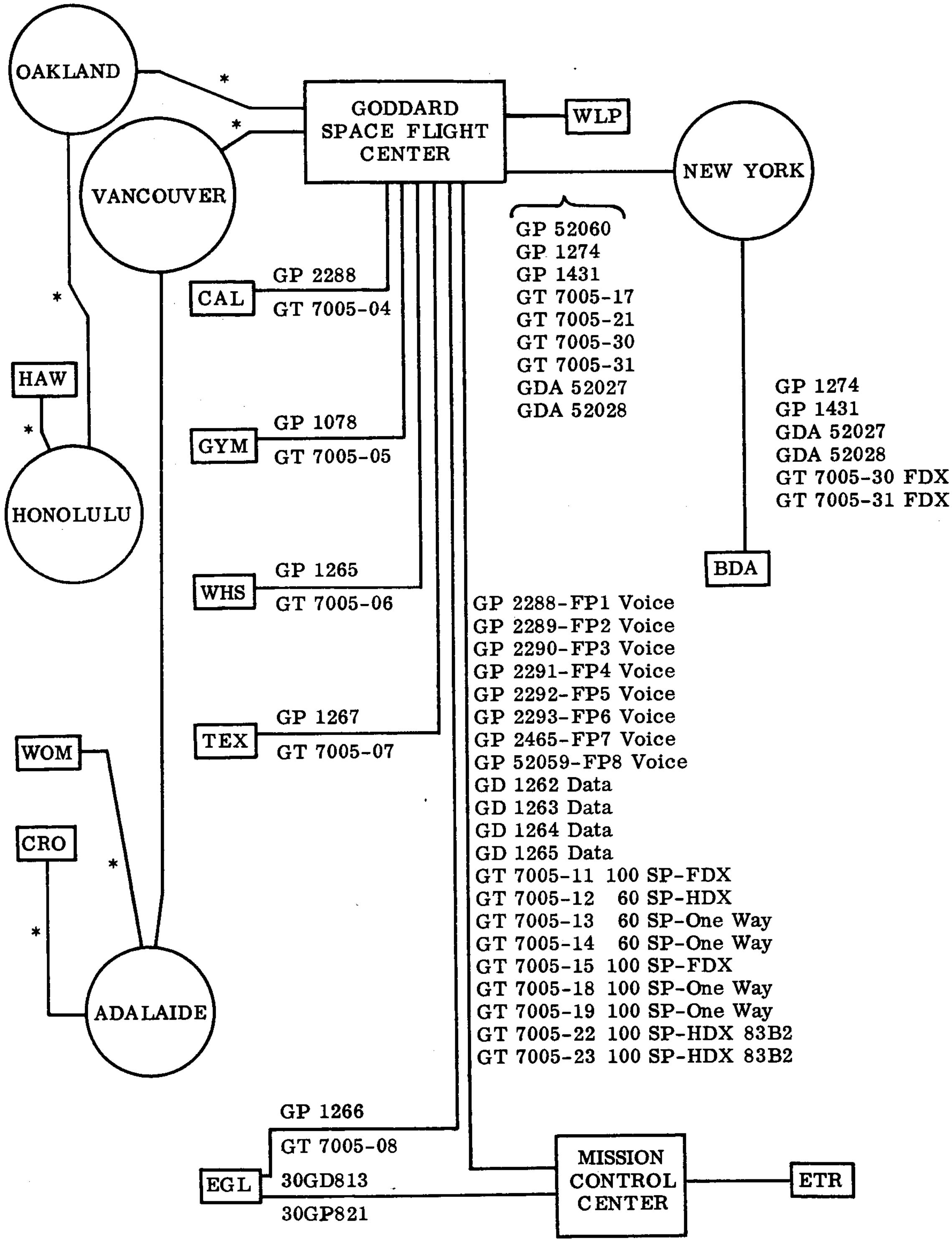
The launch, tracking, and reentry phases were supported with only minor outages of TTY and voice circuits. On May 30, the carrier failed between Sydney and Adelaide on the voice circuit to Carnarvon. The circuit was out for a period of nine minutes and was restored by patching around the faulty circuit just prior to Carnarvon's acquisition on revolution 31.

Because of a carrier failure on the receive path into GSFC between White Sands and El Paso, the voice circuit from White Sands was out for a period of 84 minutes. This failure occured during revolution 31 and prevented voice coordination for this pass.

A 2-wire to 4-wire patch was made at the switching center in Honolulu to the DOD station at South Point, Hawaii, for three passes. This extension worked very well with only very slight echo, which did not affect the users.

TTY outages affecting the mission were (1) White Sands during a pass causing the radar data to be delayed and (2) a marginal circuit with Santiago during the reentry phase. A malfunction in the circuit assurance device at the White Sands station prevented the operator from keying the transmitter and resulted in a few minutes delay in receipt of the radar data. The circuit to Santiago was not good enough for message traffic due to propagation conditions, but NASCOM was able to get the desired information from the station.

This was the first mission that was supported by the Univac 490 communication processor. All stations except the MSFN stations used this unit instead of the manual 111B tape-relay system. This system provided excellent support, exceeding expectations.



LEGEND:
FDX - Full Duplex TTY
HDX - Half Duplex TTY
* - 1 TTY, 1 Voice

Figure 6. Ground Communications Network for MSFN Support

9. NETWORK DATA REDUCTION

The network data reduction plan, as used for this mission, yielded satisfactory results in that a sufficient amount of data was received and available for system evaluation.

The data received via the NDR plan served to extend and verify the information that was received by the real-time summary message and the PLIM (Post Launch Instrumentation Message).

An important section of the NDR is the one reserved for comments and recommendations from the M&O supervisors, system engineers, and system operators. Much of the information received from this section is of the type that would not appear on an operations log and could very easily be forgotten as a result of the station postmission activity.

In general, there were very few mistakes in the transmission of the NDR messages.

At present a study is being conducted to determine if the NDR plan will be used for future missions.

APPENDIX A

ANCILLARY SUPPORT BY OTHER NETWORKS

A.1 MINITRACK DATA

The following NASA STADAN stations provided support for the SA-6 mission:

Fort Myers, Florida
Goldstone, California
Johannesburg, South Africa
Lima, Peru
Quito, Ecuador
Santiago, Chile
Woomera, Australia

A summary of the Minitrack data received from these stations is contained in table A-1. The Minitrack beacon continued transmitting for the lifetime of the vehicle. Minitrack data from Johannesburg at 20:46 GMT and Santiago at 23:28 on May 31, 1964, confirmed the orbit reentry and splash point.

A.2 OPTICAL SIGHTINGS

Following is a summary of the sightings from SAO and MOTS:

SAO (Baker-Nunn)	Date	Time (GMT)
Arequipa, Peru	5/29/64	23:05
Woomera, Australia	5/29/64	08:50
Olifantsfontein, South Africa	5/31/64	16:43
SAO (Moonwatch)		
Pretoria, South Africa	5/31/64	16:09
MOTS		
Johannesburg, South Africa	5/31/64	16:06
Woomera, Australia	5/31/64	08:48

A.3 NORAD CONTACTS

NORAD (North American Air Defense Command) stations reported that the following contacts were made during the SA-6 mission:

Station	Date	Time (GMT)	Station	Date	Time (GMT)
Laredo	5/28/64	12:28	Laredo	5/30/64	11:32
Laredo	5/28/64	17:44	Moorestown	5/30/64	11:38
San Diego	5/28/64	18:36	Laredo	5/30/64	13:05
Laredo	5/28/64	18:40	Ft. Stewart	5/30/64	13:09
Trinidad Island	5/28/64	18:50	Moorestown	5/30/64	13:11
Laredo	5/28/64	19:17	Laredo	5/30/64	14:38
Laredo	5/28/64	20:14	Ft. Stewart	5/30/64	14:42
Ft. Stewart	5/29/64	01:16	Moorestown	5/30/64	14:43
Laredo	5/29/64	12:01	Laredo	5/30/64	16:12
Moorestown	5/29/64	12:08	Laredo	5/30/64	17:44
Laredo	5/29/64	13:34	Laredo	5/30/64	19:16
Moorestown	5/29/64	13:40	Moorestown	5/31/64	11:03
Ft. Stewart	5/29/64	15:12	Laredo	5/31/64	12:28
Laredo	5/29/64	16:41	Ft. Stewart	5/31/64	12:34
Moorestown	5/29/64	16:45	Ft. Stewart	5/31/64	14:06
Laredo	5/29/64	18:15	Laredo	5/31/64	15:34
Laredo	5/29/64	19:48	Laredo	5/31/64	18:39
			Laredo	5/31/64	18:40

Table A-1. SA-6 Minitrack Data

Date	Station	First Observation (GMT) (hr:min:sec)	Last Observation (GMT) (hr:min:sec)	Total Observations
5/28/64	Johannesburg	17:41:32	17:43:28	30
5/28/64	Lima	21:57:47	21:58:06	16
5/28/64	Johannesburg	22:23:14	22:24:10	15
5/29/64	Santiago	01:08:06	01:08:13	8
5/29/64	Santiago	02:41:30	02:41:38	9
5/29/64	Lima	07:21:50	07:22:19	21
5/29/64	Quito	08:56:45	08:56:45	1
5/29/64	Woomera	11:27:20	11:28:27	17
5/29/64	Fort Myers	12:05:10	12:05:18	3
5/29/64	Woomera	13:00:41	13:01:30	6
5/29/64	Fort Myers	16:45:17	16:45:25	3
5/29/64	Johannesburg	17:15:47	17:16:11	7
5/29/64	Lima	21:30:22	21:30:36	15
5/29/64	Johannesburg	21:55:52	21:56:20	16
5/30/64	Santiago	00:40:10	00:40:16	7
5/30/64	Santiago	02:13:16	02:13:23	8
5/30/64	Lima	06:52:59	06:53:13	15
5/30/64	Woomera	10:57:52	10:58:33	9
5/30/64	Fort Myers	11:35:31	11:35:39	3
5/30/64	Woomera	12:30:51	12:30:55	2
5/30/64	Fort Myers	16:14:50	16:14:58	3
5/30/64	Johannesburg	16:45:18	16:45:38	6
5/30/64	Lima	20:59:07	20:59:07	1
5/30/64	Johannesburg	21:24:26	21:24:46	5
5/31/64	Santiago	00:08:14	00:08:14	1
5/31/64	Santiago	01:41:00	01:41:00	1
5/31/64	Lima	06:19:36	06:19:44	3
5/31/64	Woomera	10:23:24	10:24:04	9
5/31/64	Fort Myers	11:00:49	11:00:57	3
5/31/64	Woomera	11:55:56	11:56:00	2
5/31/64	Fort Myers	15:38:39	15:38:47	4
5/31/64	Johannesburg	16:09:02	16:09:14	3
5/31/64	Lima	20:20:58	20:21:02	2
5/31/64	Johannesburg	20:46:11	20:46:19	3
5/31/64	Santiago	23:28:15	23:28:15	1